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a guide to Forest Diseases of Southwestern Conifers

James W. Walters

Forest Insect and Disease Management
State and Private Forestry
Southwestern Region, Forest Service, USDA

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Cover photo: Numerous witches' brooms caused by pinyon dwarf mistletoe resulted in death of this tree.

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Introduction

Southwestern forests harbor a great variety of tree diseases. Forest diseases are often inconspicuous. Most damage results from growth reduction and gradual deterioration rather than direct tree mortality. In the Southwest, forest diseases cause more annual timber volume loss than insects and fire combined. The inconspicuous nature of forest diseases often causes land managers and homeowners to underestimate or overlook their significant role in the forest environment. Recognition and identification of a forest disease are the first steps in resolving a pathological problem.

This guide provides non-technical information about some common forest diseases in the Southwest. No attempt has been made to provide information on all Southwestern forest diseases, nor to provide technical, in-depth knowledge of their life cycles. References are provided for readers interested in obtaining more information about a particular disease. All forest diseases covered in this guide occur in Arizona and/or New Mexico. Local distribution and all hosts of forest diseases occuring in the Southwest are not provided, as many are not well-defined. Comments pertaining to occurrence of certain diseases are included.

Many forest diseases are host specific or occur mainly on one tree species. Diseases often can be identified by determining the species of tree they occur on. Little (1950) has developed a guide to identifying native Southwestern trees. Evidence of a forest disease occurs as signs or symptoms. Signs of a disease are any observable part of the pathogen, such as sporophores (conks, mushrooms, etc.), mycelial mats, mistletoe shoots, and rhizomorphs. Symptoms of a disease are expressed by the host as a result of infection by a pathogen. Symptoms include needle discoloration, cankers, galls, and witches' brooms. Forest diseases included in this guide have been grouped in seven major categories as listed in the index. The following information is provided for each disease: (1) principal host(s); (2) description of disease, including signs and symptoms (photographs when available); (3) damage resulting from infection; (4) comments on importance and/or occurrence. A host index of the diseases is provided.

Dwarf Mistletoes

General Information

Dwarf mistletoes are parasitic, flowering plants that infect many species of Southwestern conifers. These plants develop a root system within an infected branch or bole; thus, removal of shoots will not kill the mistletoe. Aerial shoots vary in size from small nubs protruding through the bark to branching shoots of nearly 1 foot in length. Shoots vary in color from orange to green or brown. Symptoms of dwarf mistletoe include swelling of the branch or bole at the point of infection, bole cankers, and witches' brooms. This disease spreads by explosive fruits which shoot tiny, sticky seeds into surrounding branches and trees.

Dwarf mistletoes cause reduced growth and increased mortality of infected trees. Growth reduction varies from 10 to 60 percent when healthy trees are compared to moderate or heavily infected trees. Heavily infected trees produce fewer cones, less seed, and seed viability is reduced when compared to healthy trees. Information about five species of dwarf mistletoe that occur in Arizona and New Mexico is provided in this guide. Several other species of dwarf mistletoe are found in Arizona; however, their distribution is quite limited. For more information on mistletoes of Arizona and New Mexico, refer to Walters' (1976) publication. The biology of dwarf mistletoes has been covered in detail by Hawksworth and Wiens (1972).

SOUTHWESTERN DWARF MISTLETOE, *Arceuthobium vaginatum* subsp. *cryptopodum* (Fig. 1)

Principal host— ponderosa pine *(Pinus ponderosa).*

Description— shoots are orange to reddish brown and vary from about 4 inches to 1 foot in length.

Damage— this species is the most damaging disease in the Southwest; one study of about 1,600 ponderosa pine trees in New Mexico indicated growth of heavily infected, dominant trees was reduced by 35 percent in 55-year-old stands and 52 percent in 140-year-old stands over a 5-year period (Hawksworth 1961).

Occurrence— southwestern dwarf mistletoe occurs throughout Arizona and New Mexico; surveys indicate this disease is present on at least 2.5 million acres of commercial ponderosa pine forests in the Southwest.

(Fig. 1.) Witches' brooms caused by *A. vaginatum* subsp. *cryptopodum* infections of a ponderosa pine (Above); a female southwestern dwarf mistletoe plant on a ponderosa pine branch (L).

(Fig. 2) Female (top) and male (bottom) *A. apachecum* plants on the bole of a southwestern white pine.

APACHE DWARF MISTLETOE, *Arceuthobium apachecum* (Fig. 2)

Principal host— southwestern white pine *(Pinus strobiformis).*

Description— shoots of this species are 1 to 2 inches long and yellow-green to reddish in color.

Damage— similar to that listed in the general information section.

Occurrence— from east-central Arizona and New Mexico southward; not abundant within its range.

PINYON DWARF MISTLETOE, *Arceuthobium divaricatum* (Fig. 3)

Principal host— pinyon *(Pinus edulis, P. monophylla, P. cembroides).*

Description— shoots are usually 3 to 5 inches long and green to brown in color; witches' brooms are not well-defined.

Damage— similar to that listed in the general information section; however, damage is somewhat less evident.

Occurrence— occurs in Arizona (except southwestern part) and New Mexico (except northwest part).

(Fig. 3) Pinyon dwarf mistletoe *(A. divaricatum)* on a pinyon branch.

DOUGLAS-FIR DWARF MISTLETOE, *Arceuthobium douglasii* (Fig. 4)

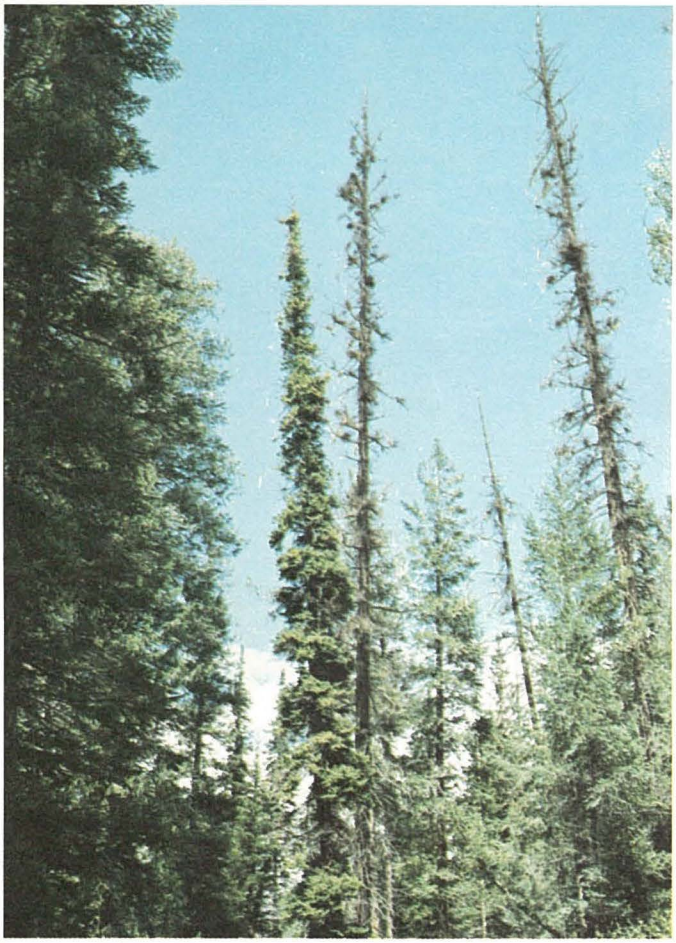
Principal host— Douglas-fir *(Pseudotsuga menziesii).*

Description— shoots are very small (usually less than 1 inch) and often quite dense along a branch; shoots are olive green in color; witches' brooms are very dense and frequently large.

Damage— similar to that listed in the general information section; however, growth reduction and tree mortality are more pronounced.

Occurrence— common throughout Douglas-fir forests of Arizona and New Mexico.

(Fig. 4) Numerous large witches' brooms caused by *A. douglasii* infections of Douglas-fir (Above); Douglas-fir dwarf mistletoe infecting a host branch; note the small size of mistletoe shoots (R).



WESTERN SPRUCE DWARF MISTLETOE
Arceuthobium microcarpum (Fig. 5)

Principal hosts— Engelmann and blue spruce *(Picea engelmannii* and *P. pungens).*

Description— shoots are about 2 inches long, but may be up to 4 inches in length; shoots are green to purple in color; witches' brooms are small, dense, and often quite numerous.

Damage— similar to that listed in the general information section.

Occurrence— southeast and north-central Arizona and southwest New Mexico; distribution is limited to several National Forests.

(Fig. 5) Numerous small, dense witches' brooms caused by *A. microcarpum* infections of Engelmann spruce (Above); two western spruce dwarf mistletoe plants on a host branch (L).

True Mistletoes

General Information

True mistletoes are parasitic, flowering plants and have the following characteristics: (1) most species have leaves on the mistletoe plant; (2) shoots vary from about 6 inches to 1 foot in length; (3) seeds are eaten by birds and thus disseminated through droppings; (4) many of the required nutrients are produced by the plant; (5) shoots have woody stems. Because many of the required nutrients are produced by the mistletoe plant, effects of these diseases are less severe than those caused by dwarf mistletoe. Growth rate of infected trees is reduced and occasionally trees may die from extremely heavy infections. True mistletoes are relatively easy to distinguish due to their large size. Swellings often occur at infection sites, and branch distortions are not uncommon. Two species of true mistletoe occur on junipers and one on cypress in the Southwest.

JUNIPER MISTLETOE, *Phoradendron juniperinum* (Fig. 6)

Principal hosts— alligator juniper, one-seed juniper, Utah juniper, Rocky Mountain juniper, red-berry juniper (*Juniperus* sp.).

Description— shoots are 3 to 12 inches in length and orange in color; the mistletoe plant usually has a rounded appearance; this species is readily identified by the absence of leaves.

Damage— similar to that listed in the general information section.

Occurrence— occurs throughout the Southwest; this species is the most common of true mistletoes.

(Fig. 6) *P. juniperinum* plant on a juniper branch; note the absence of leaves on the mistletoe plant.

PHORADENDRON CAPITELLATUM (Fig. 7)

Principal hosts— alligator juniper, red-berry juniper, and Utah juniper *(Juniperus* sp.*)*.

Description— shoots are green in color and 3 to 12 inches in length; the mistletoe plants usually have a rounded appearance; the distinguishing characteristic of this species is presence of small leaves with a hairy leaf surface.

Damage— similar to that listed in the general information section.

Occurrence— from central Arizona southward and south-central New Mexico.

(Fig. 7) *P. capitellatum* plant on a juniper branch; note the large size of mistletoe shoots and presence of small leaves on the plant.

PHORADENDRON BOLLEANUM subsp. *densum*

Principal host—Arizona cypress *(Cupressus arizonica)*.

Description— similar to *P. capitellatum,* except leaves have smooth surface.

Damage— similar to that listed in the general information section.

Occurrence— central Arizona.

Foliage Diseases

General Information

Foliage diseases are usually of local importance in the Southwest. Adverse climatic conditions, particularly low humidity, do not favor development or spread of foliage diseases in Arizona and New Mexico. Past outbreaks of these diseases have usually been confined to relatively small areas. Tree mortality resulting from outbreaks has been minimal. Many foliage diseases affect only old needles, leaving current year foliage to sustain the affected tree. Partial defoliation for several consecutive years will reduce growth of infected trees and may predispose trees to other disease or insect problems. Total defoliation results in death of the tree.

Foliage diseases are spread by tiny spores. At certain times of the year, spores are released from fruiting bodies that develop on infected needles. The spores are carried by wind to nearby susceptible trees. Symptoms of a foliage disease may include witches' brooms, discolored needles, and premature needle cast. Each fall, conifers cast some of their old needles which often turn yellow or red before being cast. This annual needle drop should not be mistaken for foliage disease symptoms, as it is a natural occurrence.

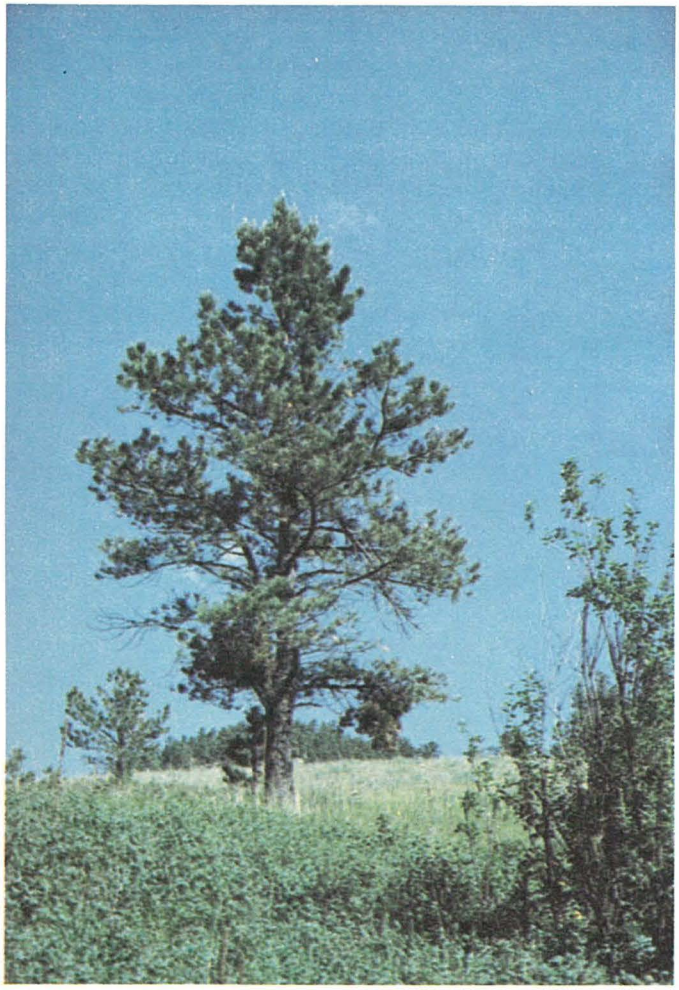
ADELOPUS NEEDLE CAST *Adelopus gaumanni*

Principal host— Douglas-fir *(P. menziesii).*

Description— symptoms are yellow to brown foliage, thin crown, and premature needle cast; needles vary from yellow-green to mottled yellow-green or brown; symptoms appear from spring to early summer; lower surface of infected needle has numerous tiny black fruiting bodies protruding from the stomata; fruiting bodies often have the appearance of black streaks on each side of the lower needle surface; as infection progresses, needles turn brown and are prematurely cast.

Damage— growth reduction and mortality can result from consecutive years of defoliation.

Occurrence— Arizona and New Mexico.



ELYTRODERMA NEEDLE CAST, *Elytroderma deformans* (Fig. 8)

Principal host— ponderosa pine *(P. ponderosa).*

Description— needles turn reddish brown in spring, followed by formation of fruiting bodies which appear as dark streaks on the dead needles; a flagging effect often develops from tufted, discolored needles; infected needles may be prematurely cast.

Damage— may cause growth reduction and some mortality of weakened trees.

Occurrence— Arizona and New Mexico.

(Fig. 8) Witches' brooms in the lower crown of ponderosa pine, caused by *Elytroderma deformans* (Above); tufted, discolored foliage caused by *E. deformans* infection of pinyon (L).

(Fig. 9) Black mycelial felts cover Engelmann spruce needles infected by *H. nigra*.

SNOW BLIGHT, *Herpotrichia nigra* (Fig. 9)

Principal hosts— Engelmann and blue spruce, Douglas-fir, white fir, alpine fir, and corkbark fir *(Picea engelmannii, P. pungens, P. menziesii, Abies concolor,* and *A. lasiocarpa).*

Description— only occurs on needles covered by snow for long periods; thus, it is confined to the lower portion of trees; dense, felt-like growth of brown to black mycelium forms on snow-covered twigs and needles; this disease is most commonly found in spring to early summer.

Damage— high mountain forests of Arizona and New Mexico.

TRUE FIR NEEDLE CAST, *Lirula abietis-concoloris* (Fig. 10)

Principal hosts— white fir, alpine fir, and corkbark fir *(A. concolor* and *A. lasiocarpa).*

Description— during spring and early summer, brown fruiting bodies form in the groove on upper needle surface; affects only older needles (not current year), which are prematurely cast.

Damage— may cause growth reduction and reduces value of Christmas trees.

Occurrence— Arizona and New Mexico.

(Fig. 10) White fir needles infected by *L. abietis-concoloris;* note the upper needle grove is filled with dark spore bodies.

PINE NEEDLE CAST, *Lophodermella cerina*

Principal host— ponderosa pine *(P. ponderosa)*.

Description— symptoms are reddish-brown foliage and a thin crown; infected needles have a distinct band about midway back from the tip; the distal portion of an infected needle dies and turns bright reddish brown; as the infection progresses, needles die and are prematurely cast.

Damage— some growth loss and mortality can result from consecutive years of defoliation.

Occurrence— Arizona and New Mexico.

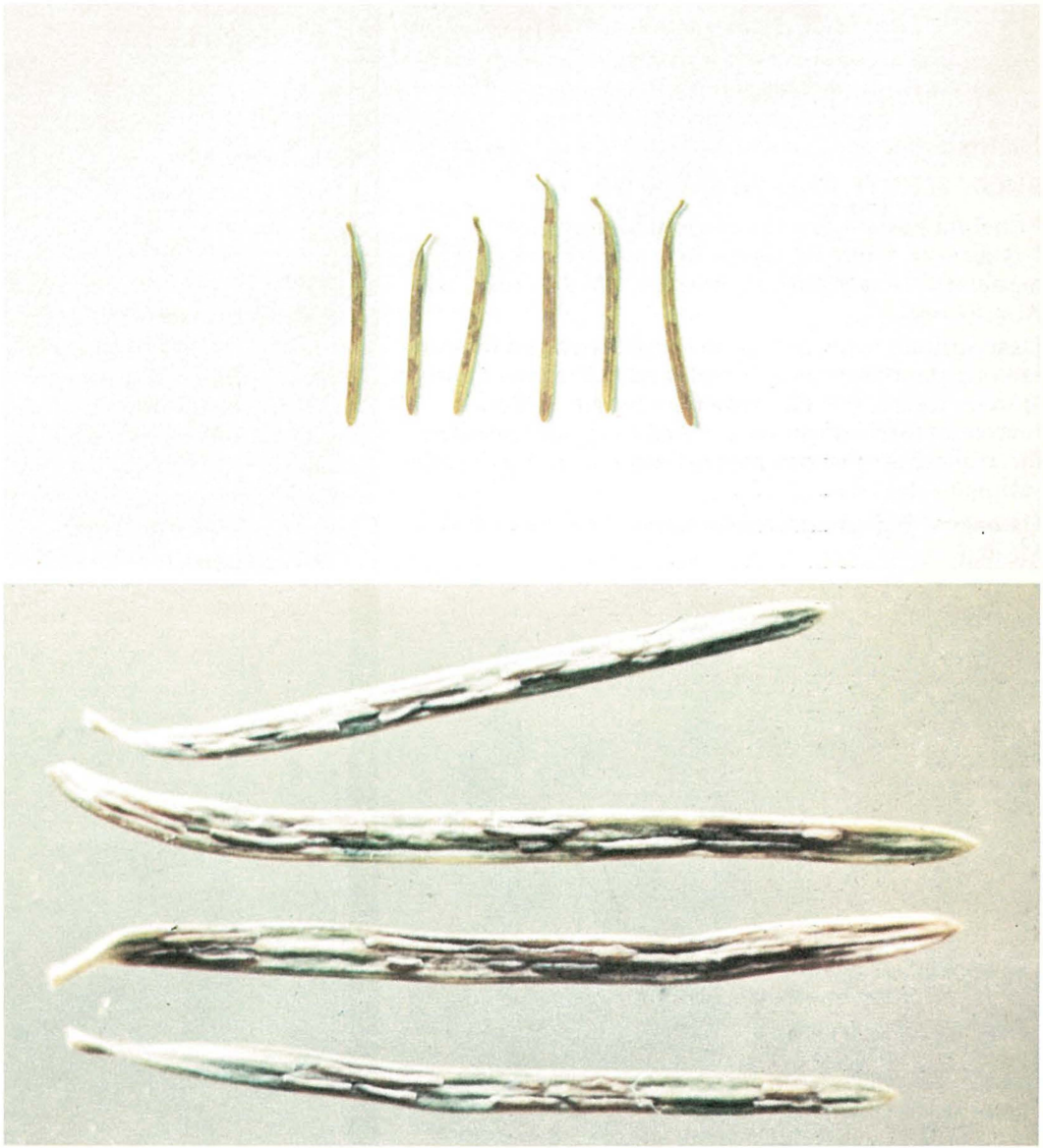
RHABDOCLINE NEEDLE CAST, *Rhabdocline pseudotsugae* (Fig. 11)

Principal host—Douglas-fir *(P. menziesii)*.

Description— symptoms are chlorotic foliage, thin crown, and premature needle cast; small, yellow spots form on needles in fall and winter; yellow spots turn red-brown during winter months; fruiting bodies are orange-brown, raised pustules, usually on the lower side of the infected needle; fruiting bodies are most prevalent in spring to early summer.

Damage— growth reduction results if defoliation occurs for several years.

Occurrence— Arizona and New Mexico.



(Fig. 11) The mottled appearance of Douglas-fir needles is characteristic of infection by *R. pseudotsugae* (Above); raised pustules on infected Douglas-fir needles (R).

Stem and Branch Diseases

General Information

Stem diseases are caused by bacteria and fungi (particularly rust fungi). These diseases often cause some type of host deformity, such as a canker, gall, or witches' broom. Evidence of stem diseases is most prevalent during spring and summer; however, signs or symptoms of the disease may be present throughout the year.

The most common stem diseases are rusts. This category of fungi is unusual because some require an alternate host to complete the life cycle. Some rusts produce blisters on an infected branch or bole. Blisters are mycelial sacs containing fungal spores. In most cases, spores produced on the primary host will not infect another primary host, but infect the alternate host. Spores produced on the alternate host then infect the primary host species. Control of rusts is difficult, as both primary and alternate hosts provide a source of inoculum to spread the disease.

Stem diseases usually do not cause rapid tree mortality. More frequently they reduce growth and kill branches, which over long periods results in death of the tree. Stem diseases often are entry points for decay fungi and sometimes form a weak point in the tree bole. High winds may break trees off at the infection point.

ATROPELLIS CANKER, *Atropellis piniphila* (Fig. 12)

Principal host— ponderosa pine *(P. ponderosa).*

Description— this disease causes a perennial canker on branches and boles; a blue-black stain of sapwood is associated with the canker; heavy resin flow often accompanies the canker; fruiting bodies are small, black, shrunken structures on the bark; most common in dense stands of saplings and poles.

Damage— cankers may girdle some trees causing mortality; wood is degraded by cankers and stain.

Occurrence— Arizona and New Mexico.

(Fig. 12) The sunken, black canker on this young ponderosa pine was caused by *A. piniphila*.

(Fig. 13) A rough, globose gall on Douglas-fir caused by *B. pseudotsugae*.

BACTERIAL GALL OF DOUGLAS-FIR, *Bacterium pseudotsugae* (Fig. 13)

Principal host— Douglas-fir *(P. menziesii)*.

Description— forms globose galls which have a rough surface; galls are persistent and most common on young, low-vigor trees; size of galls varies from tiny to several inches in diameter.

Damage— galls persist for long periods before killing the tree; may cause distortion of branches; mortality is most common in very young trees.

Occurrence— Arizona and New Mexico.

BLUE STAIN, *Ceratocystis* sp. (Fig. 14)

Principal host— conifers.

Description— various species cause a blue stain in trees and wood products; often associated with bark beetle galleries; fruiting bodies appear as stiff, black hairs, 1 to 2 mm long, with a bulbous base that may be embedded in the wood; fruiting bodies frequently develop under loose bark or in insect galleries.

Damage— may cause tree mortality; most important damage is discoloration of lumber and logs, resulting in degrade; does not significantly reduce wood strength.

Occurrence— Arizona and New Mexico.

(Fig. 14) Blue-stained wood in a ponderosa pine log.

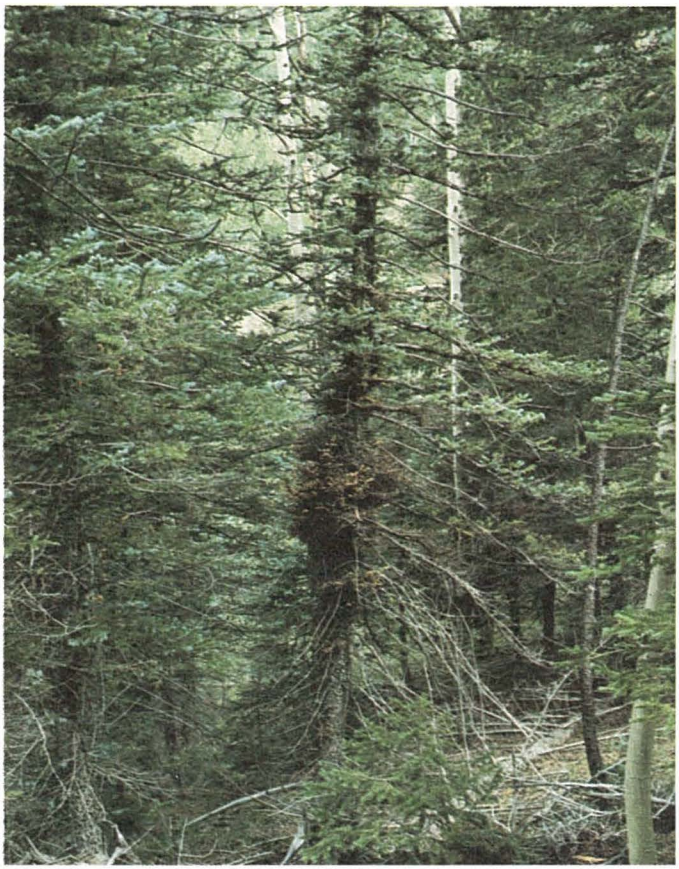
SPRUCE BROOM RUST, *Chrysomyxa arctostaphyli* (Fig. 15)

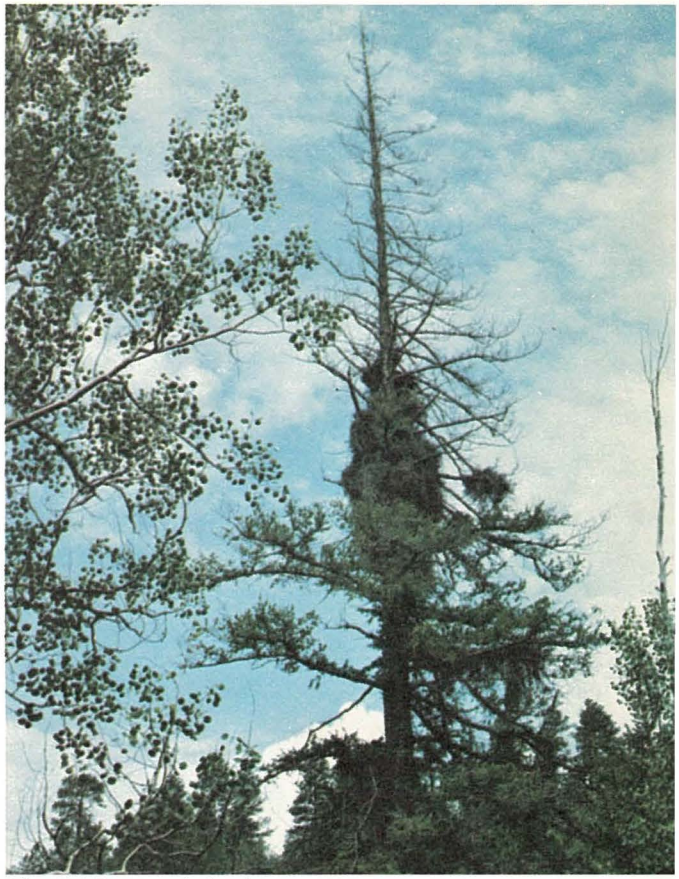
Principal host— Engelmann and blue spruce *(P. engelmannii* and *P. pungens).*

Description— causes witches' brooms in the infected tree; needles in the broom are yellow-green and are cast annually; alternate hosts are bearberry, manzanita, etc. *(Arctostaphylos* sp.*).*

Damage— some growth loss associated with brooming; spiketop and tree mortality also occur; brooms act as infection courts for decay fungi.

Occurrence— Arizona and New Mexico.





(Fig. 15) Dense witches' brooms caused by spruce broom rust *(C. arctostaphyli)* infecting Engelmann spruce; broom rust has caused a spiketop in this tree (Above); small yellowish needles in the broom are characteristic of broom rust infections (L).

PINYON BLISTER RUST, *Cronartium occidentale*

Principal host— pinyons *(P. edulis, P. monophylla, P. cembroides).*

Description— causes branch and bole swellings in the lower crown of an infected tree; most common on young trees; alternate hosts are currant-gooseberry *(Ribes* sp.*);* fruiting bodies may be distinct blisters or broad layers under the bark with tiny sacs protruding through bark cracks; blisters are white, while the spores they contain are orange.

Damage— frequently results in mortality, especially in young trees.

Occurrence— Arizona and New Mexico.

JUNIPER RUSTS, *Gymnosporangium* sp. (Fig. 16)

Principal hosts— junipers *(Juniperus* sp.*).*

Description— several species of *Gymnosporangium* occur in the Southwest; these rusts often cause witches' brooms, spindleshaped swellings, or woody galls on infected branches; branch distortion may occur from infection by some species; common alternate hosts are apple *(Malus* sp.*),* hawthorn *(Crataegus* sp.*).* and serviceberry *(Amelanchier* sp.*).*

Damage— some branch and tree mortality associated with heavy infection; growth reduction and unsightly appearance also result from infection.

Occurrence— Arizona and New Mexico.

(Fig. 16) Large witches' broom caused by *Gymnosporangium* sp. infecting this juniper (Above); brooms are often very large and quite dense (L).

FIR BROOM RUST, *Melampsorella caryophyllacearum* (Fig. 17)

Principal hosts— white fir, alpine fir, and corkbark fir *(A. concolor* and *A. lasiocarpa).*

Description— causes upright, compact witches' brooms and trunk or branch swellings; the yellow needles in a witches' broom are cast annually; the bark on old bole and branch swellings dies and cracks; alternate hosts are chickweeds *(Stellaria* sp. and *Cerastium* sp.*).*

Damage— growth loss and volume loss due to defect; also, some mortality of infected trees occurs; most important effect is the infection court for decay fungi provided by brooms and other infections.

Occurrence— Arizona and New Mexico (especially Sandia Mountains, Cibola National Forest).

(Fig. 17) Witches' brooms in this white fir are caused by fir broom rust (Above); yellowish stunted needles are found in the broom (L).

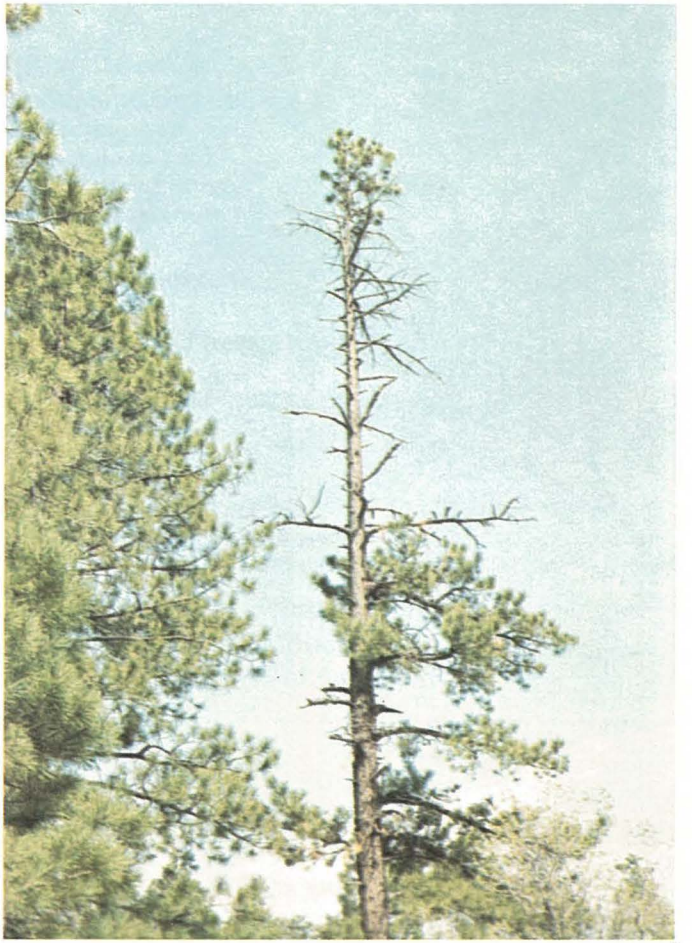
LIMB RUST, *Peridermium filamentosum* (Fig. 18)

Principal host— ponderosa pine *(P. ponderosa).*

Description— white blisters containing orange spores form on infected branches during spring or summer; infection often starts at midcrown and moves upward and downward; the alternate host for one race of limb rust is Indian paintbrush *(Castilleja* sp.*),* while a second race goes directly from pine to pine.

Damage— branch mortality progresses from midcrown upward and downward until the infected tree dies; infected trees may persist for long periods before death.

Occurrence— Arizona and New Mexico.



(Fig. 18) The window-like appearance of a ponderosa pine crown is caused by limb rust (Above); the small white sacs protruding through the bark break open, releasing orange spores (R).

Trunk Rots

General Information

Trunk rots are second to dwarf mistletoes as the most destructive diseases in Southwestern conifers. Because these diseases are inside an infected tree, evidence of their presence is sometimes difficult to detect. In certain situations, the amount of damage caused by trunk rot becomes obvious only when a tree is cut. Boring a tree with an increment borer is one method of determining whether trunk rot is present. Some fungi, causing rots, produce highly visible conks or fruiting bodies which simplify determination of their presence. Slash and nearby stumps may have signs of rot fungi, indicating their presence in the area. Trunk rots often occur in association with wounds, particularly those caused by fire, logging, and lightning.

These fungi spread by spores that are disseminated from conks or mushrooms. Fruiting bodies are most frequently produced during wet, warm periods. Timber volume loss associated with trunk rot results from destruction of wood fiber and discoloration of wood. Direct tree mortality is not commonly associated with trunk rot infections. However, infected trees are much more likely to be broken off or blown over during windy periods.

POUCH FUNGUS, *Cryptoporus volvatus (Polyporus volvatus)* (Fig. 19)

Principal host— ponderosa pine *(P. ponderosa).*

Description— causes light gray discoloration in outer sapwood; annual sporophores are leathery and pouch-like; smooth upper surface is white to light brown; lower surface is covered by a hard membrane which eventually deteriorates, forming an opening for release of spores.

Damage— decay is limited to immediate area of conk; no economic loss involved with this rot.

Occurrence— commonly found in recently dead trees throughout Arizona and New Mexico.

(Fig. 19) Small, pouch-like sporophores on this ponderosa pine indicate presence of *C. volvatus* fungus.

WESTERN RED ROT, *Dichomitus squalens (Polyporus anceps)*

Principal host—ponderosa pine *(P. ponderosa).*

Description—decay forms a star-like pattern on log ends; advanced decay is characterized by elongated white pockets; pockets may have black flecks in them; conk is crust-like, white, and usually occurs on underside of logs and fallen trees; also found on dead branches of living trees.

Damage—extensive volume loss results from cull of infected logs.

Occurrence—Arizona and New Mexico.

INDIAN PAINT FUNGUS, *Echinodontium tinctorium* (Fig. 20)

Principal host— white fir *(A. concolor)*.

Description— decay is a brown, fibrous, stringy mass; sporophores are usually associated with branch stubs; the perennial, hoof-shaped conk has a hard, cracked, black upper surface; lower surface is gray to light brown with downward-directed spines; interior of conk is red.

Damage— substantial timber volume loss results from this disease, especially in overmature, mixed conifer forests; it is the major cause of cull in white fir.

Occurrence— widespread in Arizona and New Mexico.

(Fig. 20) Large reddish conks are commonly produced by the *E. tinctorium* heartrot fungus (Above); conks often appear below branch stubs (R).

RED HEARTROT, *Haematostereum sanguinolenta (Stereum sanguinolentum)* (Fig. 21)

Principal hosts— white fir, alpine fir, corkbark fir, and Engelmann spruce *(A concolor, A. lasiocarpa,* and *P. engelmannii).*

Description— decay is soft and brown in color; conks are common on the underside of fallen dead branches and on log ends; annual conks are thin and leathery, with crust-like layers; upper surface is gray to light brown and zoned; lower surface is gray to brown and roughened; conks are small (2 inches) and seldom found on living or dead standing trees.

Damage— heartrot causes substantial cull and loss of timber volume.

Occurrence— Arizona and New Mexico.

(Fig. 21) This rather non-descript conk protruding from bark cracks is produced by the fungus *H. sanguinolenta* on alpine fir.

RED RING ROT, *Phellinus pini (Fomes pini)* (Fig. 22)

Principal hosts— most conifers, particularly Douglas-fir and southwestern white pine.

Description — decay has spindle-shaped white pockets parallel to the wood grain; these are separated by firm red wood; as decay progresses, pockets join and form a white fibrous mass; perennial conk is usually 3 to 12 inches across and shelving; upper surface is dark brown to black and concentric; lower surface is yellow-brown with pores; frequently associated with branch stubs; swollen knots filled with mycelia are often formed on infected trees; resin flow from knots is common.

Damage— results in cull of infected trees; substantial loss of timber volume may occur in heavily infected areas.

Occurrence— Arizona and New Mexico.

(Fig. 22) These shelving conks are signs of *Phellinus pini* on an Engelmann spruce tree.

Root and Butt Rots

General Information

Root and butt rots affect most species of Southwestern conifers. These fungus diseases commonly produce signs of infection on or near the host tree. Infection signs include mushrooms, conks, and mycelial mats under the bark of the root collar. Signs are most easily found in summer or early fall and particularly during wet periods. Root and butt rots may cause the host tree to show symptoms such as needle discoloration and resin flow around the root collar.

Fungi causing root and butt rots are spread by tiny spores released from fruiting bodies, such as mushrooms or conks. The spores are wind-disseminated and frequently enter host trees at basal wounds. Fire scars and logging wounds are common entry points for fungi. Another method of spread is by root contact between healthy and infected trees. A root rot usually spreads outward from an infection center, killing susceptible trees. This mortality results in roughly circular pockets of dead and dying trees. Butt rots seldom kill the host tree, but predispose it to windthrow or more pathogenic diseases.

Root rots also are associated with windthrow, particularly of mature and overmature trees. These diseases sometimes are beneficial thinning agents in the natural forest environment. Weakened trees may be attacked and killed, leaving the more vigorous, healthy trees in the forest. Planted trees are more susceptible to root rots, and plantations have suffered heavy losses in some situations. Trees under stress from transplanting, drought, compaction, or other disease problems often succumb to root rot fungi.

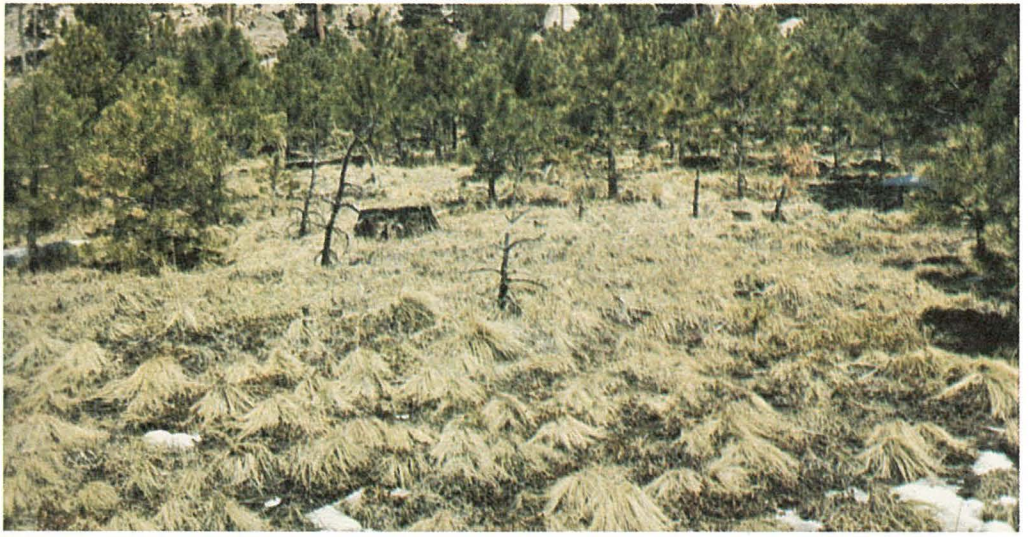
SHOESTRING ROOT ROT, *Armillaria mellea* (Fig. 23)

Principal hosts— all conifers.

Description— white mycelial fans form between the bark and wood on roots and root collar; decayed wood often has black zone lines in it; resin flows from the root collar; honey-colored mushrooms appear in late summer or early fall near the base of an infected tree or stump; the disease is spread by root contact and rhizomorphs; rhizomorphs are tiny, string-like mycelial structures that grow through the soil and along roots or stumps.

Damage— mortality is prevalent in plantations and trees under stress; often associated with other disease or insect problems; predisposes infected trees to windthrow.

Occurrence— Arizona and New Mexico.



(Fig. 23) This typical root rot center in a ponderosa pine plantation is caused by *A. mellea;* the disease is spreading from the stump at left center which was the source of infection (Above); white mycelial mats under the bark at the root collar indicate presence of *A. mellea* (L).

BROWN CUBICAL ROTS, *Coniophora* sp.

Principal hosts— most conifers.

Description— decay results in brown cubical cracking with mycelia on cube faces; the annual sporophore is flat and brown with a white margin; sporophore surface is wavy to smooth and usually occurs on the underside of logs.

Damage— some timber volume is lost due to butt rot; susceptibility to windthrow is increased.

Occurrence— Arizona and New Mexico.

RED BELT FUNGUS, *Fomitopsis pinicola (Fomes pinicola)* (Fig. 24)

Principal hosts— most conifers.

Description— decay is red to yellow-brown cubes with white mycelial mats on cube faces; conks are perennial, leathery to woody, and flat shelving; upper surface of conk is brown to black with a red zone near the margin; lower surface is white with round pores; occurs on dead trees, stumps, and occasionally as a sap rot in living trees.

Damage— some timber volume loss due to heartrot and sap rot behind wounds in living trees.

Occurrence— one of the most common rots on dead trees in Arizona and New Mexico.

(Fig. 24) These conks, caused by *F. pinicola*, are extremely common on stumps and dead trees throughout the Southwest.

RED-BROWN BUTT ROT, *Inonotus tomentosus (Polyporus tomentosus)*

Principal hosts— ponderosa pine and Engelmann spruce *(P. ponderosa* and *P. engelmannii).*

Description— decay has elongated, spindle-shaped, white pockets in wood; end of roots often appear honey-combed; mushroom is small (1-2" cap), firm, yellow to brown, with a hairy upper surface and thick central stalk; usually occurs on the ground near infected trees.

Damage— increases susceptibility to windthrow and causes some timber volume loss due to butt rot.

Occurrence— Arizona and New Mexico.

VELVET-TOP FUNGUS, *Phaeolus schweinitzii (Polyporus schweinitzii)* (Fig. 25)

Principal hosts— most conifers.

Description— decayed heartwood is yellow to red-brown brittle cubes; in late summer or fall, an annual sporophore may appear on soil, roots, or lower trunk; sporophore is circular with central stalk; upper surface is velvety, concentric, and rusty brown with a yellowish margin; lower surface is yellow-green with large pores; this disease is frequently associated with fire scars.

Damage— may move up the tree in a decay column; increases susceptibility to windthrow; some tree mortality occurs.

Occurrence— very common in Arizona and New Mexico.

(Fig. 25) A large sporophore of *P. schweinitzii;* note the yellowish-white margin and rusty brown upper surface; upper surface is velvety to the touch.

CAULIFLOWER FUNGUS, *Sparassis radicata*

Principal hosts— most conifers, particularly Douglas-fir.

Description— yellowish-brown decay; fruiting body is fleshy and white to yellowish, consisting of a series of cauliflower-like branches with flattened tips; large central stalk gives rise to branches; usually on the ground under infected tree.

Damage— increases susceptibility to windthrow; some timber volume loss due to butt rot.

Occurrence— Arizona (particularly southern part) and New Mexico.

Non-biological Diseases

Some of the most common disease problems in the Southwest are caused by non-biological agents. These diseases may be related to natural causes or man's actions. Some symptoms of non-biological diseases are discolored needles, bark cracks, and dried needle tips. Although there are numerous abiotic agents that adversely affect Southwestern conifers, only a few are covered in this guide. Identification of non-biological diseases is often difficult, as many cause similar symptoms.

CHLORIDE DAMAGE (Fig. 26)

Principal hosts— all conifers; however, susceptibility varies.

Description— browning of needle tips and eventual death of the needle; characteristically occurs on downhill side of road.

Damage— results in death of roadside trees.

Occurrence— Arizona and New Mexico, especially along highways to winter sports areas.

(Fig. 26) Needle tip browning caused by salt damage is often quite pronounced in ponderosa pine (Above) and white fir (L).

DROUGHT STRESS

Principal hosts— conifers.

Description— overall fading of foliage; often trees die from top downward; browning of needle tips may occur.

Damage— often results in tree mortality which is sometimes associated with other diseases or insects.

Occurrence— Arizona and New Mexico.

LIGHTNING (Fig. 27)

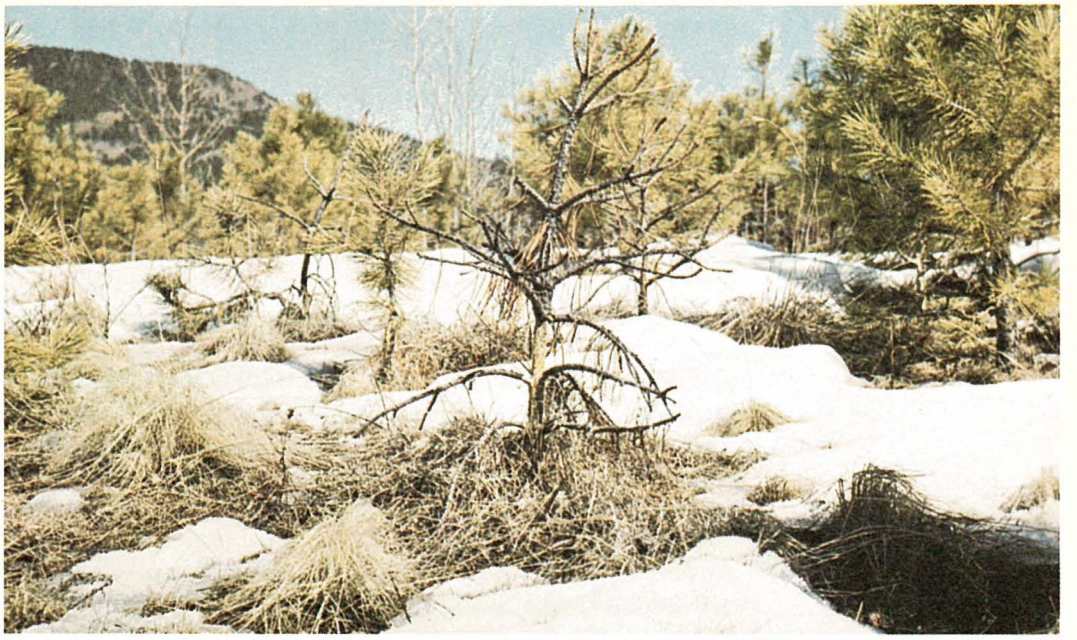
Principal hosts— most conifers.

Description— confined to large, mature trees; long cracks or a strip of bark removed from upper bole; may be burned bark along edges of the scar; tree may be broken off at point of strike.

Damage— some tree mortality occurs; often causes splits in wood and provides an infection court for decay fungi.

Occurrence— Arizona and New Mexico.

(Fig. 27) Lightning strikes often cause long cracks to form on the bole of a tree, sometimes spiraling around the bole (Above); a dead top may result from lightning strike (L).



(Fig. 28) Ponderosa pines in a plantation are particularly susceptible to rodent girdling (R); most girdling is near the base of the tree (Below).

RODENT DAMAGE (Fig. 28)

Principal hosts— conifers.

Description— small rodents remove bark on sections of the bole or girdle entire stem on small trees; porcupines chew off large sections of bark, especially in the upper crown of affected trees; usually, heavy resin flow is associated with the wound.

Damage— some tree mortality results from girdling, especially in plantations.

Occurrence— Arizona and New Mexico.

WINTER INJURY

Principal hosts— conifers.

Description— foliage turns red, especially on new growth; may be more evident in upper crown.

Damage— in larger trees, mortality is limited; however, spiketops do occur; substantial mortality may occur in seedlings.

Occurrence— Arizona and New Mexico.

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Major Host Index of Diseases

(includes most common hosts only)

Ponderosa pine *(Pinus ponderosa)*

dwarf mistletoe	*Arceuthobium vaginatum* subsp. *cryptopodum*
foliage diseases	*Elytroderma deformans*
	Lophodermella cerina
stem diseases	*Atropellis piniphila*
	Ceratocystis sp.
	Peridermium filamentosum
trunk rots	*Cryptoporus volvatus (Polyporus volvatus)*
	Dichomitus squalens (Polyporus anceps)
	Phellinus pini (Fomes pini)
root and butt rots	*Armillaria mellea*
	Coniophora sp.
	Fomitopsis pinicola (Fomes pinicola)
	Inonotus tomentosus (Polyporus tomentosus)
	Phaeolus schweinitzii (Polyprous schweinitzii)
non-biological diseases	chloride damage
	drought stress
	lightning
	rodent damage
	winter injury

Southwestern white pine *(Pinus strobiformis)*

dwarf mistletoe	*Arceuthobium apachecum*
trunk rot	*Phellinus pini*
root and butt rots	*Armillaria mellea*
	Coniophora sp.
	Phaeolus schweinitzii
non-biological diseases	all

Pinyon *(Pinus edulis)*

dwarf mistletoe	*Arceuthobium divaricatum*
stem disease	*Cronartium occidentale*
root and butt rot	*Fomitopsis pinicola*

non-biological diseases	lightning
	rodent damage
	winter injury

Douglas-fir *(Pseudotsuga menziesii)*

dwarf mistletoe	*Arceuthobium douglasii*
foliage diseases	*Adelopus gaumanni*
	Rhabdocline pseudotsugae
stem disease	*Bacterium pseudotsugae*
trunk rot	*Phellinus pini*
root and butt rots	*Armillaria mellea*
	Coniophora sp.
	Fomitopsis pinicola
	Phaeolus schweinitzii
	Sparassis radicata
non-biological diseases	all

White fir *(Abies concolor)*

foliage diseases	*Herpotrichia nigra*
	Lirula abietis-concoloris
stem disease	*Melampsorella caryophyllacearum*
trunk rots	*Echinodontium tinctorium*
	Haematostereum sanguinolenta (Stereum sanguinolentum)
root and butt rots	*Armillaria mellea*
	Coniophora sp.
	Fomitopsis pinicola
non-biological diseases	all

Alpine and corkbark fir *(Abies lasiocarpa)*

foliage disease	*Lirula abietis-concoloris*
trunk rot	*Haematostereum sanguinolenta*
root and butt rots	*Armillaria mellea*
	Coniophora sp.
non-biological diseases	all

Engelmann spruce *(Picea engelmannii)*

dwarf mistletoe	*Arceuthobium microcarpum*
foliage disease	*Herpotrichia nigra*
stem disease	*Chrysomyxa arctostaphyli*
trunk rots	*Haematostereum sanguinolenta*
	Phellinus pini
root and butt rots	*Armillaria mellea*
	Coniophora sp.
	Fomitopsis pinicola
	Inonotus tomentosus
non-biological diseases	all

Junipers and Arizona cypress *(Juniperus* sp. and *Cupressus arizonica)*

true mistletoes	*Phoradendron juniperinum*
	Phoradendron bolleanum subsp. *densum*
	Phoradendron capitellatum
stem disease	*Gymnosporangium* sp.

Glossary

Alternate host— a second host species necessary for a parasite (esp. rusts) to complete its life cycle.

Canker— a localized malformation or area of dead tissue on a host stem or branch caused by disruption of the cambium.

Chlorotic— abnormal yellowing of foliage.

Conk— a visible outgrowth of a decay fungus which represents the reproductive stage (i.e., sporophore or fruiting body).

Gall— a swelling or outgrowth produced by a plant in response to attack by a disease organism or an insect.

Infection court— an entrance point for a pathogen on a host or the site of infection by a pathogen.

Inoculum— spores or tissue of a pathogen that serve to initiate disease in a plant.

Mycelium— the vegetative part or individual strands of a fungus.

Primary host— the main host species of a parasite.

Pustule— a blister-like swelling, often containing fungal spores.

Rhizomorph— root-like strands of fungus.

Spore— a reproductive body consisting of one or a few cells.

Sporophore or fruiting body— a spore-producing or spore-supporting structure.

Witches' broom— an abnormally profuse, dense mass of host branches.

Zone lines— thread-like, dark brown or black lines formed in decayed wood.

National Forests In Arizona and New Mexico